



Collaborative Sepsis Care at Kaiser Permanente

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Agenda

Sepsis care: the KP Northern California experience

Building a learning sepsis system at KPNC

Fluid management in sepsis

Kaiser Permanente Northern California

A highly integrated healthcare delivery system



By the numbers:

- 4.1 million patients
- 9,000 physicians
- 16,000 nurses
- 21 hospitals

Sepsis: a matter of public health

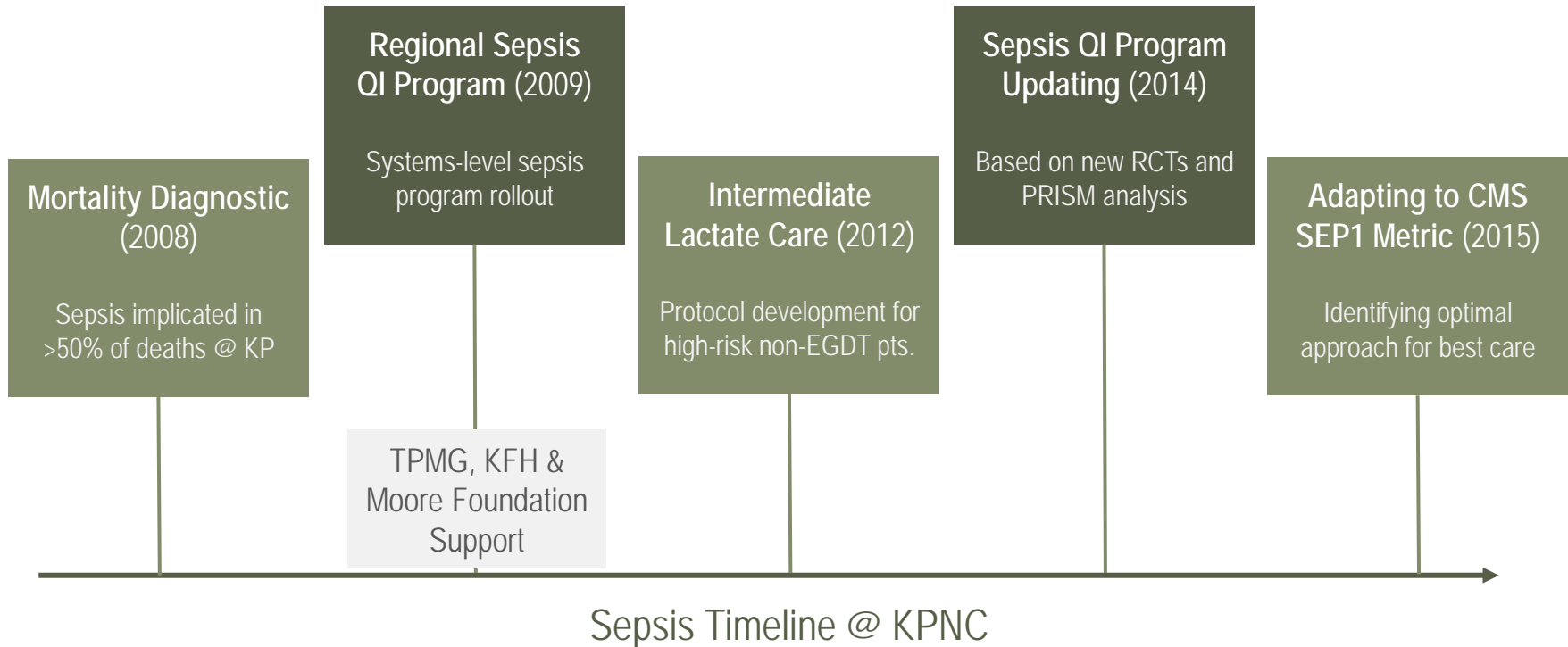
Common, costly, and deadly

- Affects >1.5m Americans and ~30m people worldwide annually;
- Associated with US healthcare costs of \$20 billion each year;
- Is a factor in at least 1 in every 3 US hospital deaths;
- Results in long-term functional and cognitive decline;
- Is one of the most common reasons for rehospitalization;
- Is poorly recognized and understood by the public.

Hershey/Kahn (NEJM 2017); Liu et al (JAMA 2013); Iwashyna et al (JAMA 2010); Mayr et al (JAMA 2017)

Sepsis: a matter of local health

A key driver of inpatient outcomes



Liu/Morehouse et al (JHM 2016)

Sepsis: coordinated implementation

Four key elements

Leadership
Alignment

Standardization

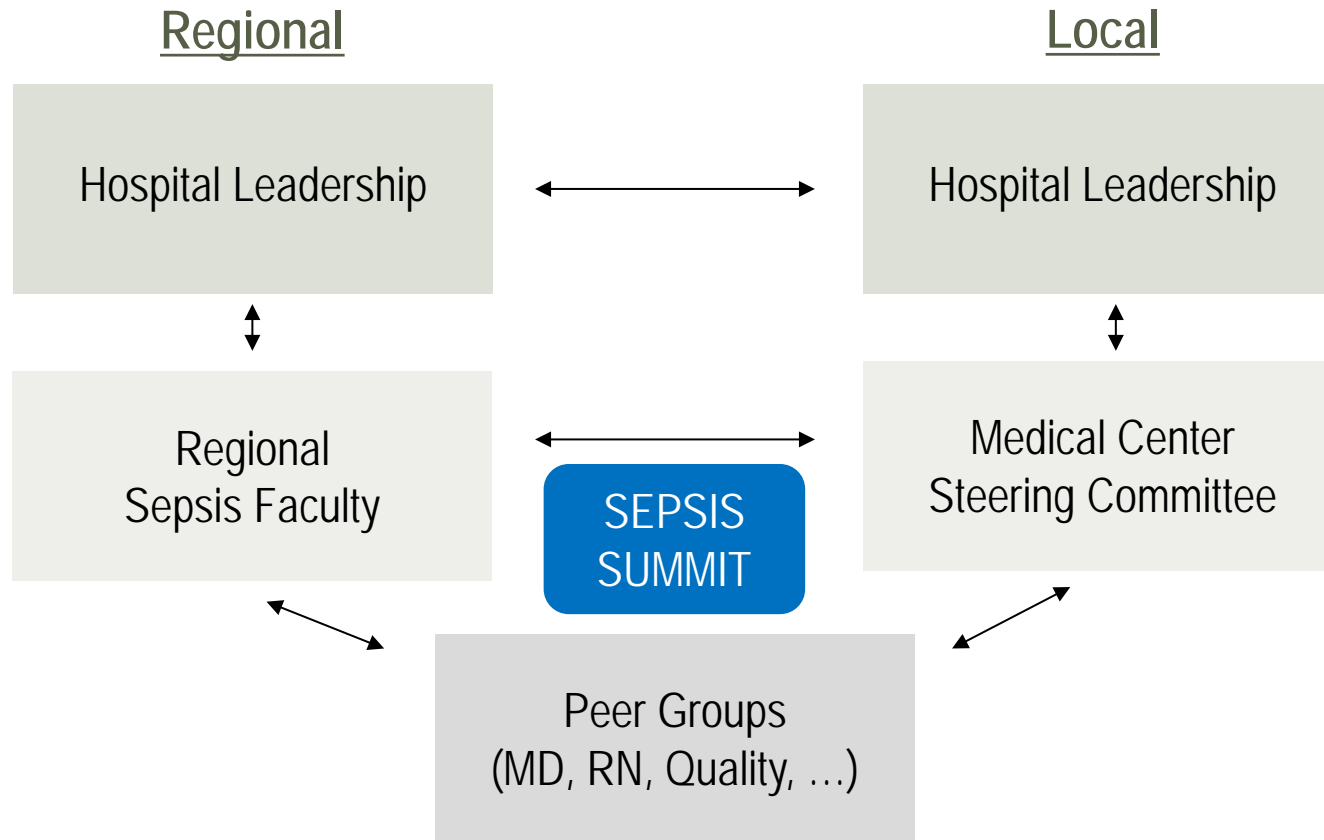


Data

Project
Management

Sepsis: coordinated implementation

Leadership Alignment



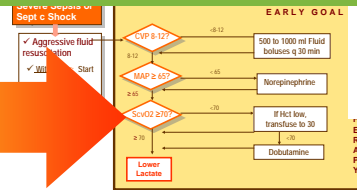
Sepsis: coordinated implementation

Standardization

Develop Teams



Adopt Algorithms



Plan Handoffs



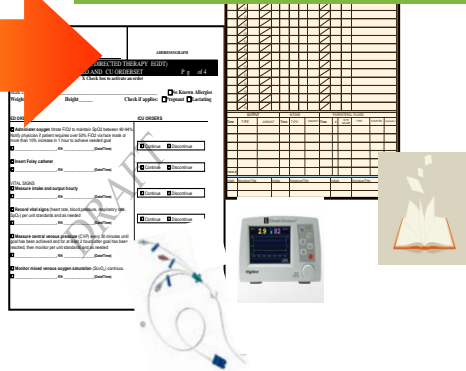
Presentation



Measure & PDSA

Sepsis Care				
Lactates	Sepsis Implementation			
Lactates on ED Blood Cultures	Team	Training	Abx. in 1 hr	CL in 2 hrs
55%	●	●	●	●
47%	●	○	○	○
44%	●	○	○	○
84%	●	○	○	○
37%	●	○	○	○
69%	●	○	○	○
91%	●	○	○	○
29%	●	○	○	○
85%	●	○	○	○
32%	●	○	○	○
77%	●	○	○	○
37%	●	○	○	○
99%	●	○	○	○
80%	●	○	○	○
36%	●	○	○	○
63%	●	○	○	○
66%	●	○	○	○
100%	○	○	○	○

Tools and Equipment



Train



Sepsis: coordinated implementation

Standardization



Playbooks to Expedite Spread

- ✓ Aim
- ✓ Standardized Processes
- ✓ Compelling Story, presentations
- ✓ Implementation Tools
- ✓ Assembling your team - optimal membership
- ✓ Checklists, sample agendas
- ✓ Training materials for MDs and staff
- ✓ Implementation timelines and measures
- ✓ Implementation, process and outcome measurement strategy

Sepsis: coordinated implementation

Standardization

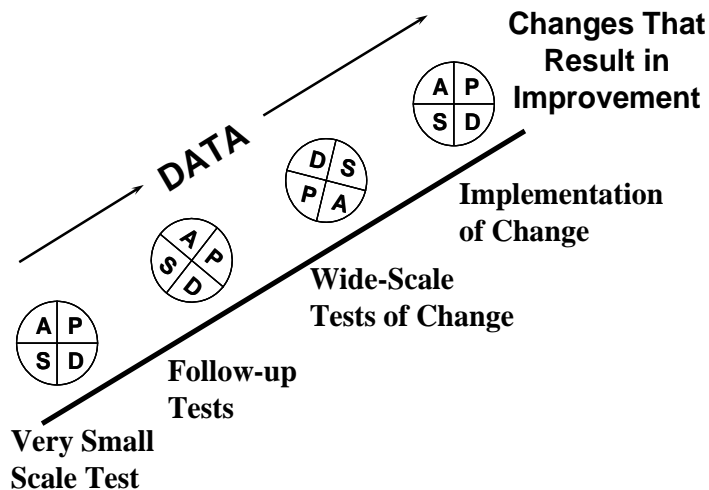


Hardwire Orders in the EMR

- ✓ Standardize order sets in EMR with antibiotics guide
- ✓ Standardize hemodynamic flowsheets with "Time Zero"
- ✓ Best practice alert to prompt lactate order with blood culture
- ✓ Automatic order of serial lactate in all admission order sets when lactate elevated

Sepsis: coordinated implementation

Project Management



Managers and champions are not project managers

Regional project managers /mentors

- Project manage at regional level
- Mentor Improvement Advisors at the Medical Center
- Run collaborative & Conduct site visits
- Monthly Newsletter & Website

Medical Center Improvement Advisors

- Run tests of change
- Oversee local project management
- Support local champions
- Regional IA meetings
- Provide local-regional feedback

Sepsis: coordinated implementation

Project Management



Collaboration: learning from those that leap ahead!

- Sepsis alerts
- Intermediate Critical Lactates
- Co-locating blood culture and lactate tubes
- IL and High Risk Bundles on CQC
- Handoff tools

Sepsis: coordinated implementation

Project Management

Quality of Team Function

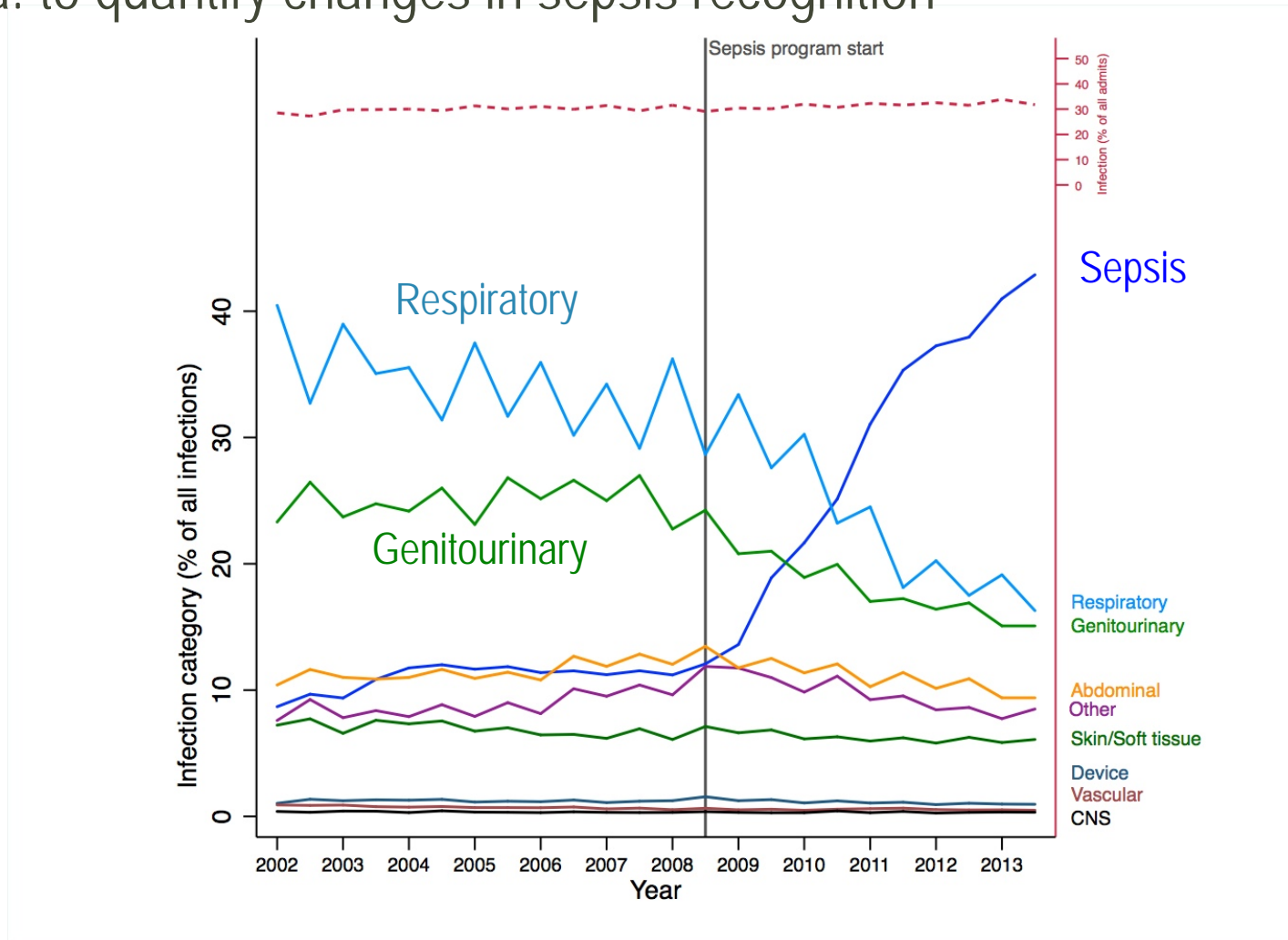
- Participation in sepsis multidisciplinary team meetings
- Discuss the status of the unit (huddles; check-ins)
- Sepsis team meeting minutes (discussion of barriers)
- Review of performance data

Partnering with frontline staff

- Can staff verbalize sepsis screening criteria?
- Do they exhibit awareness of bundle elements and are they comfortable advocating for this treatment?
- Are staff knowledgeable about performance?
- Do they feel valued?

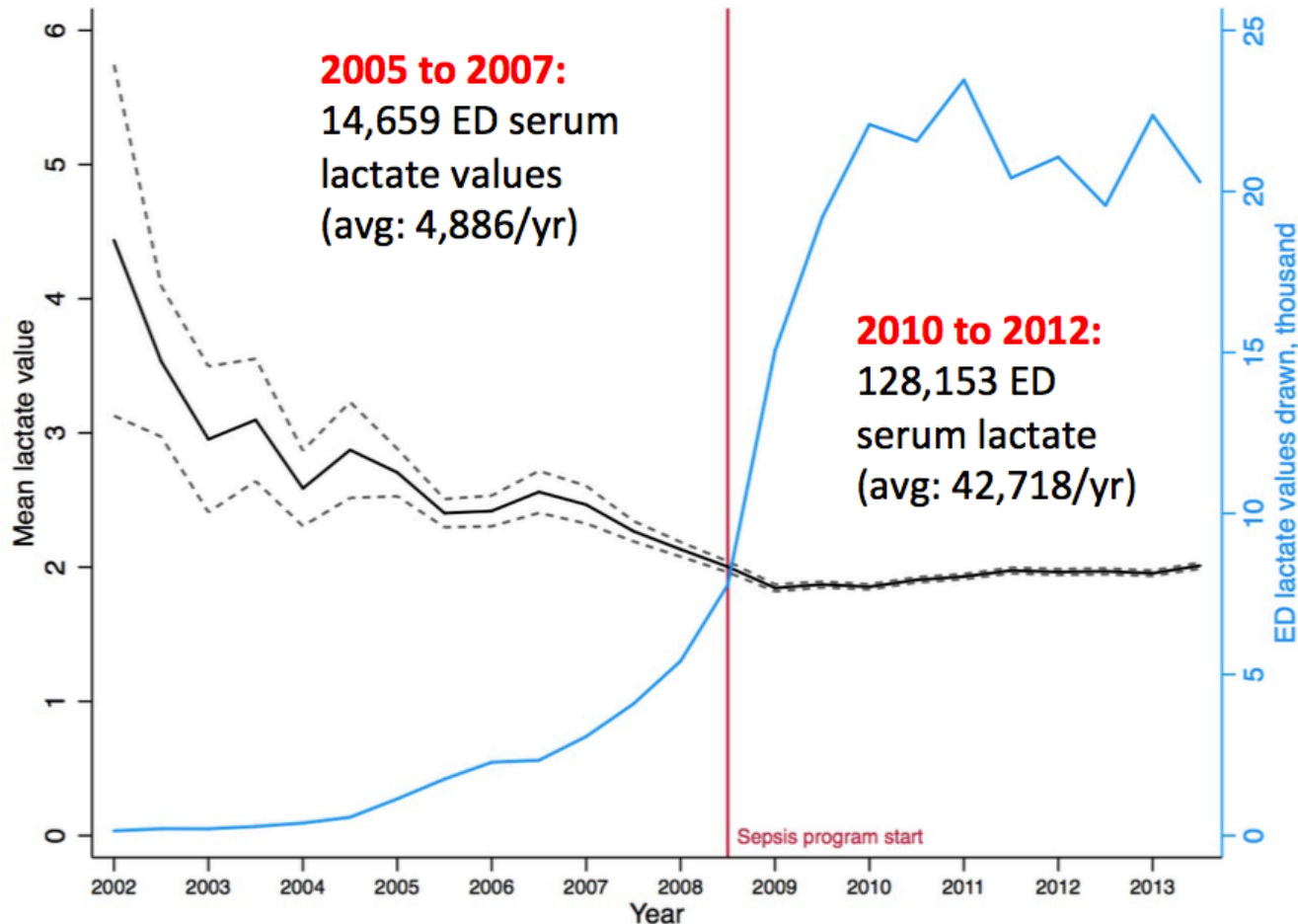
Sepsis: coordinated implementation

Data: to quantify changes in sepsis recognition



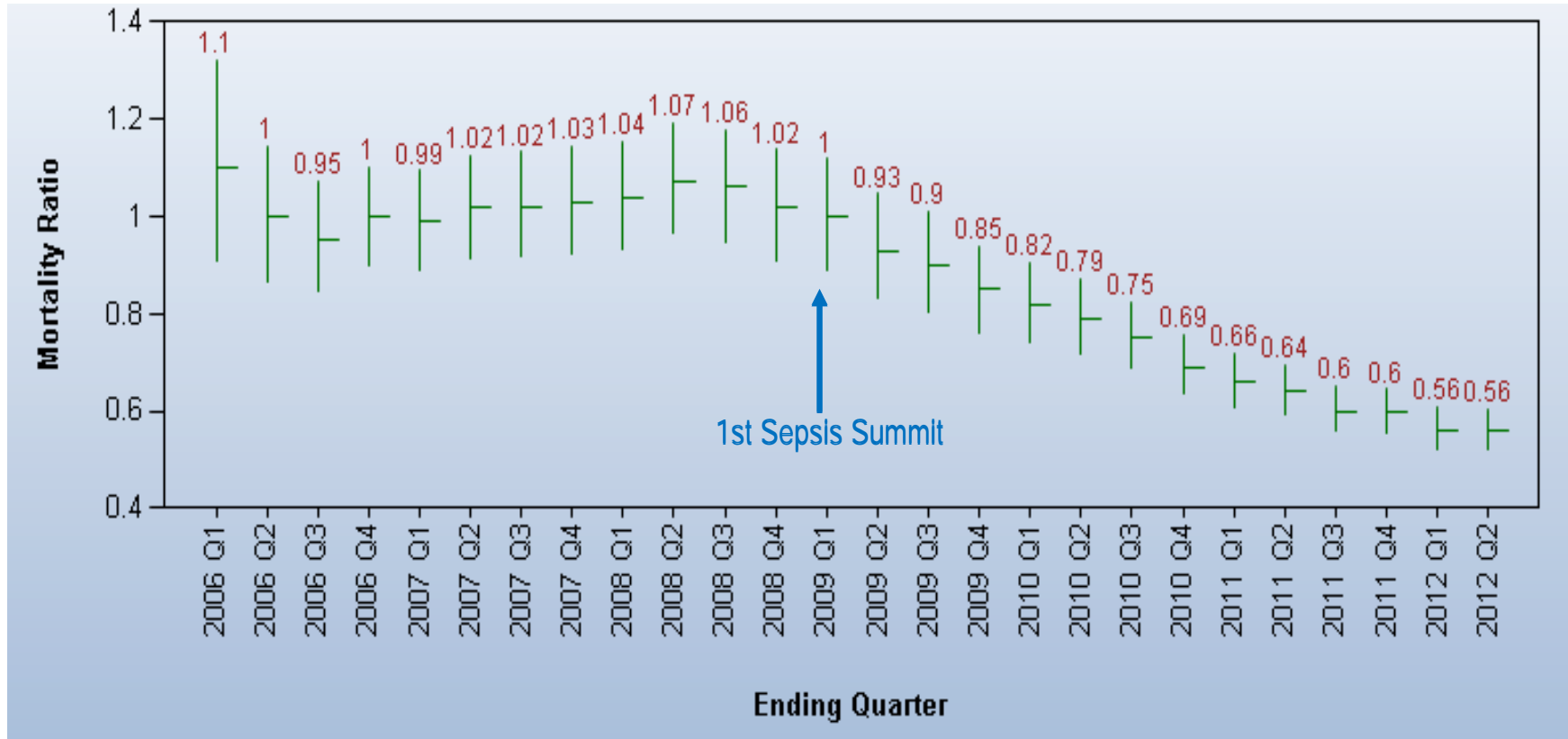
Sepsis: coordinated implementation

Data: to assess changes in use of lactate (prognostic marker)



Sepsis: coordinated implementation

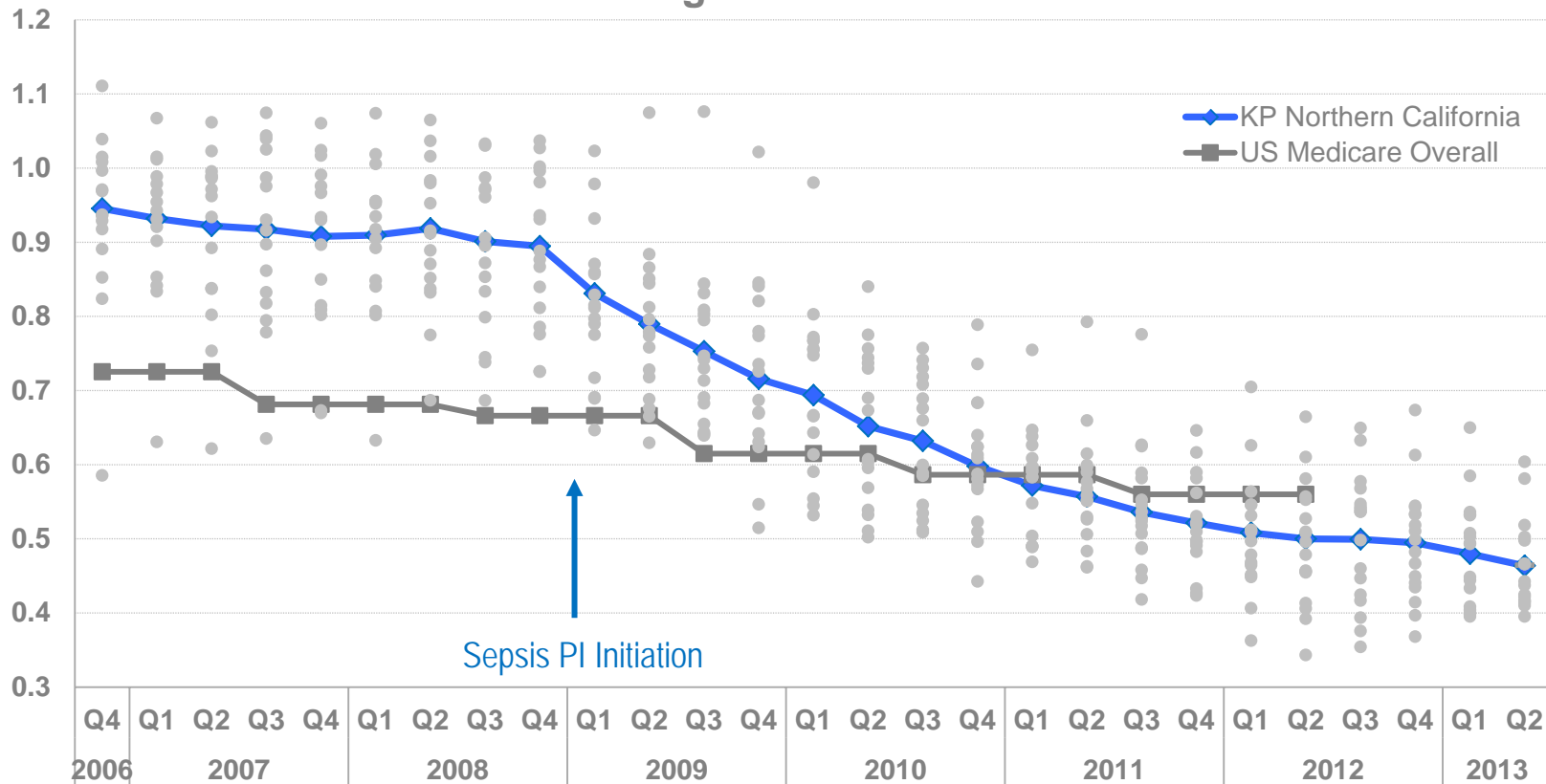
Data: to evaluate changes in sepsis risk-adjusted mortality



Sepsis: coordinated implementation

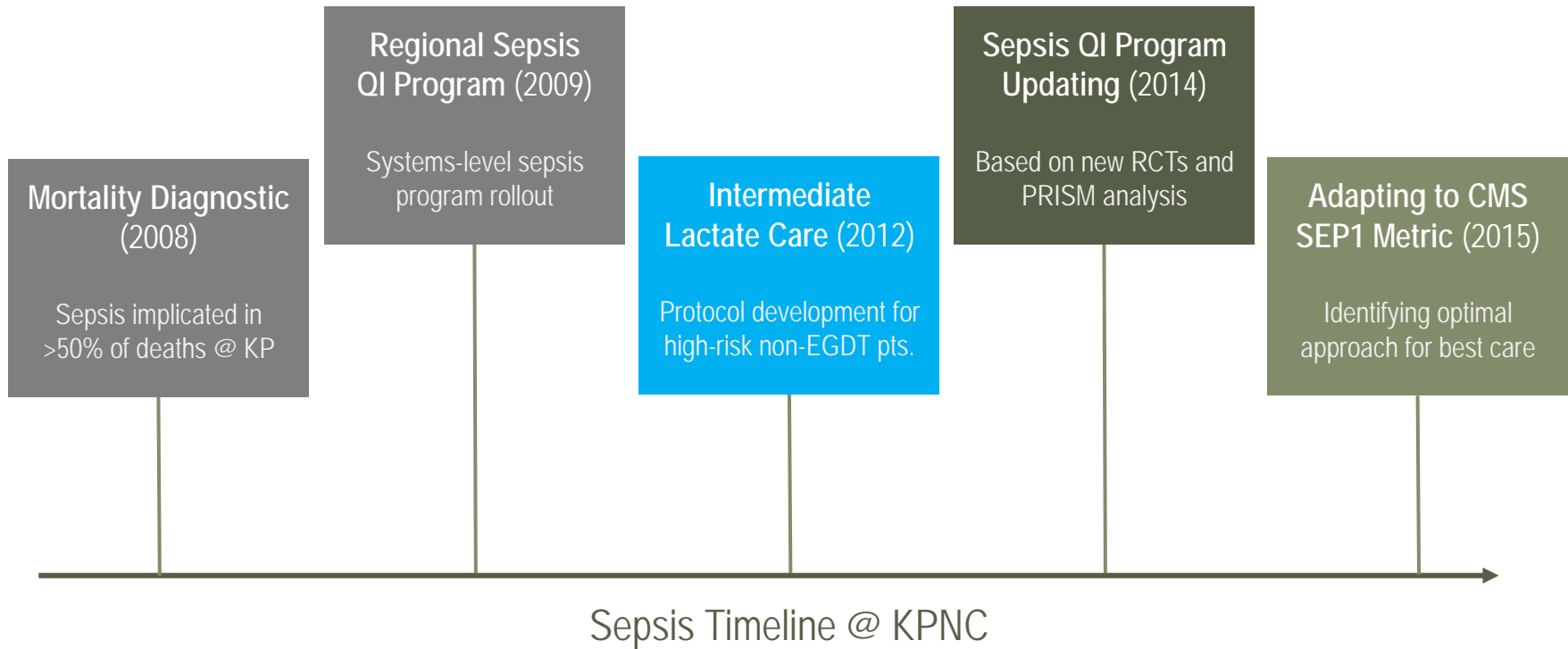
Data: to quantify changes in hospital-wide risk-adjusted mortality

Hospital Standardized Mortality Ratio (HSMR) Rolling 12 months



Sepsis: driving new discovery

Moving beyond EGDT



Liu/Morehouse et al (JHM 2016)

Sepsis: intermediate lactate patients

Intermediate risk patients and hospital mortality

	Non-EGDT eligible Lactate Level			EGDT-eligible
	Normal	Intermediate	None	
Mortality rate, %	5.3%	8.9%	10.6%	23.3%
% of all sepsis deaths	26.3%	29.6%	11.6%	22.6%

Liu et al (JAMA 2014)

Sepsis: intermediate lactate patients

Leveraging data from a large population of KPNC sepsis patients

	Study design	Sample size
Shapiro et al	Prospective	267
Howell et al	Prospective	246
Trzeciak et al	Prospective	238
Mikkelsen et al	Retrospective	415
Glickman et al	Prospective	138
Song et al	Retrospective	474
Arnold et al	Prospective	94
Liu et al	Retrospective	9,190

Puskarich et al (J Crit Care 2014)

Sepsis: intermediate lactate patients

Leveraging data from a large population of KPNC sepsis patients

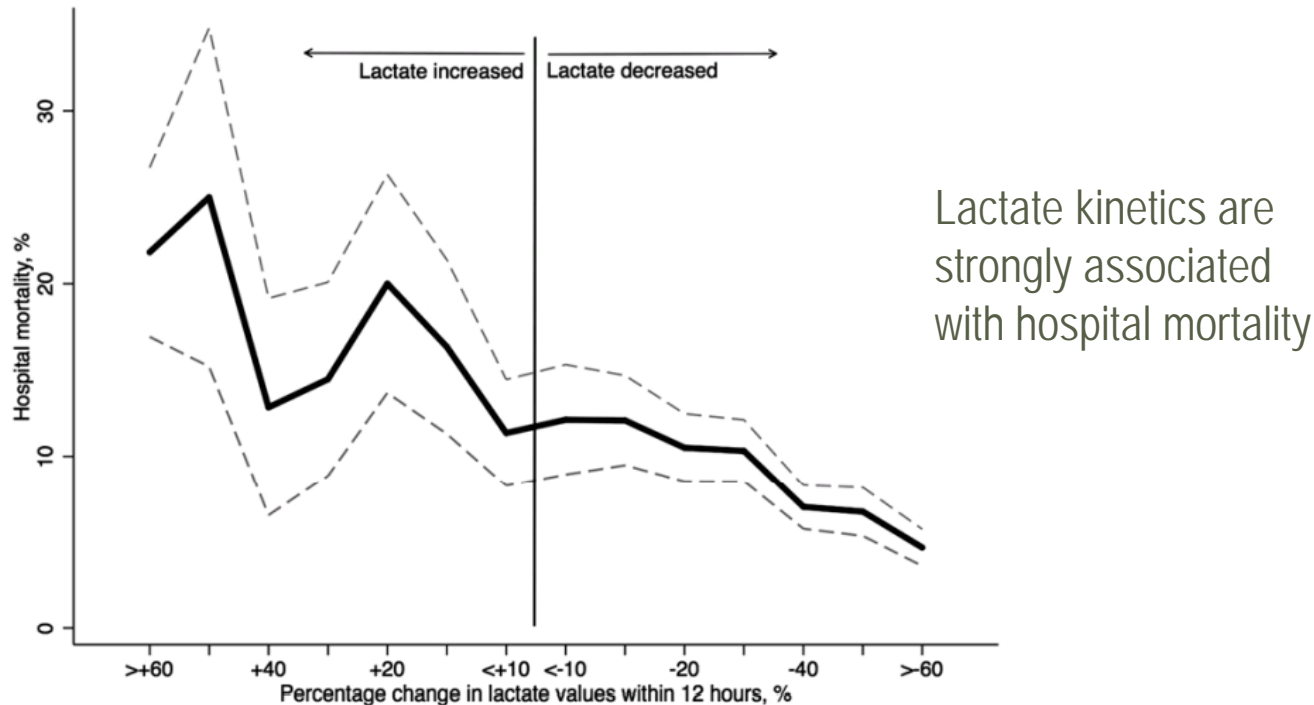
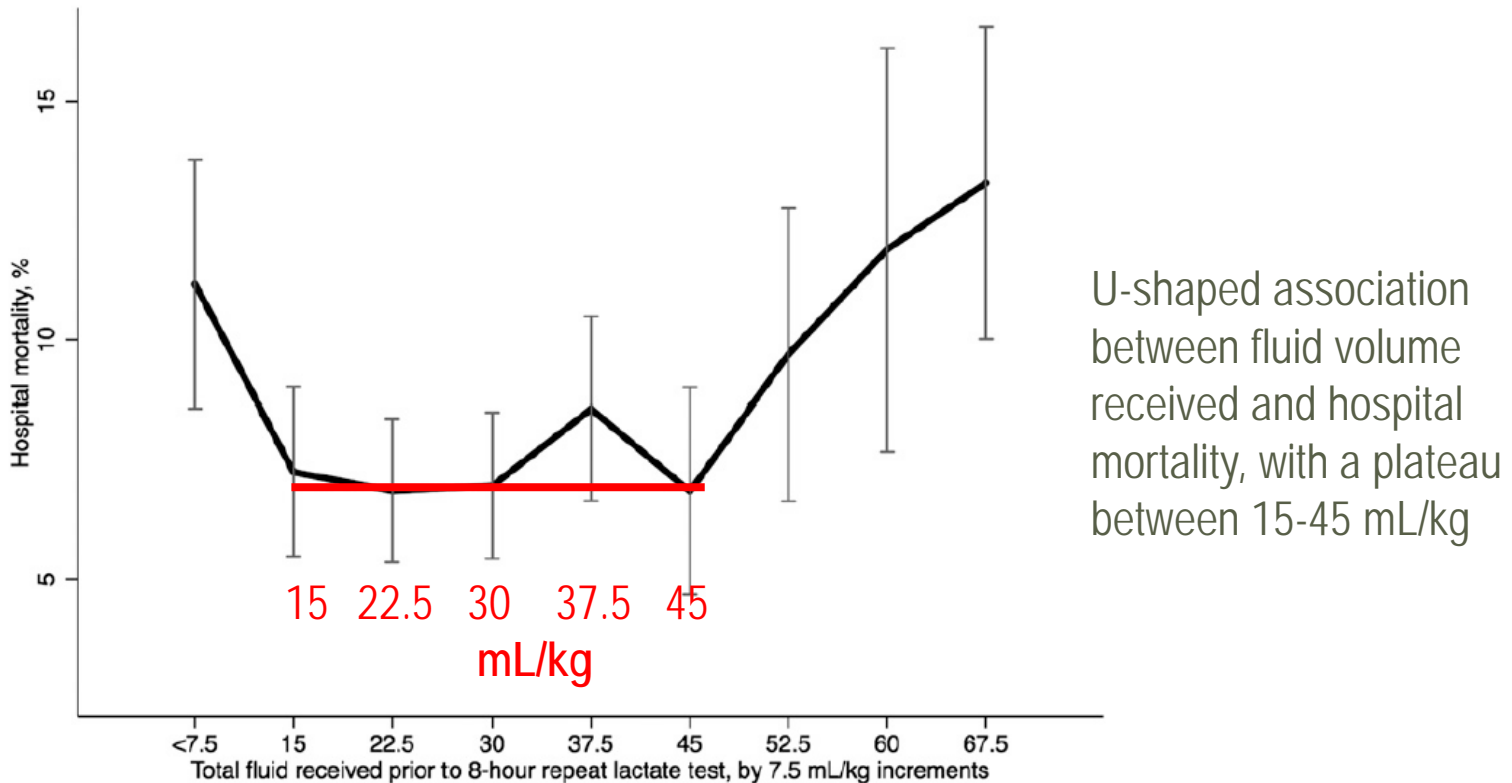


Figure 1. Mean hospital mortality (solid line) and 95% confidence interval (dotted lines) based on the magnitude of lactate change within 12 hours compared with index values. Patients with decreased lactate (across percentage strata) are represented toward the *right* of the figure, whereas those with increased lactate are toward the *left*. The vertical line demarcates increased and decreased repeat lactate values.

Liu/Morehouse et al (Annals ATS 2013)

Sepsis: intermediate lactate patients

Leveraging data from a large population of KPNC sepsis patients



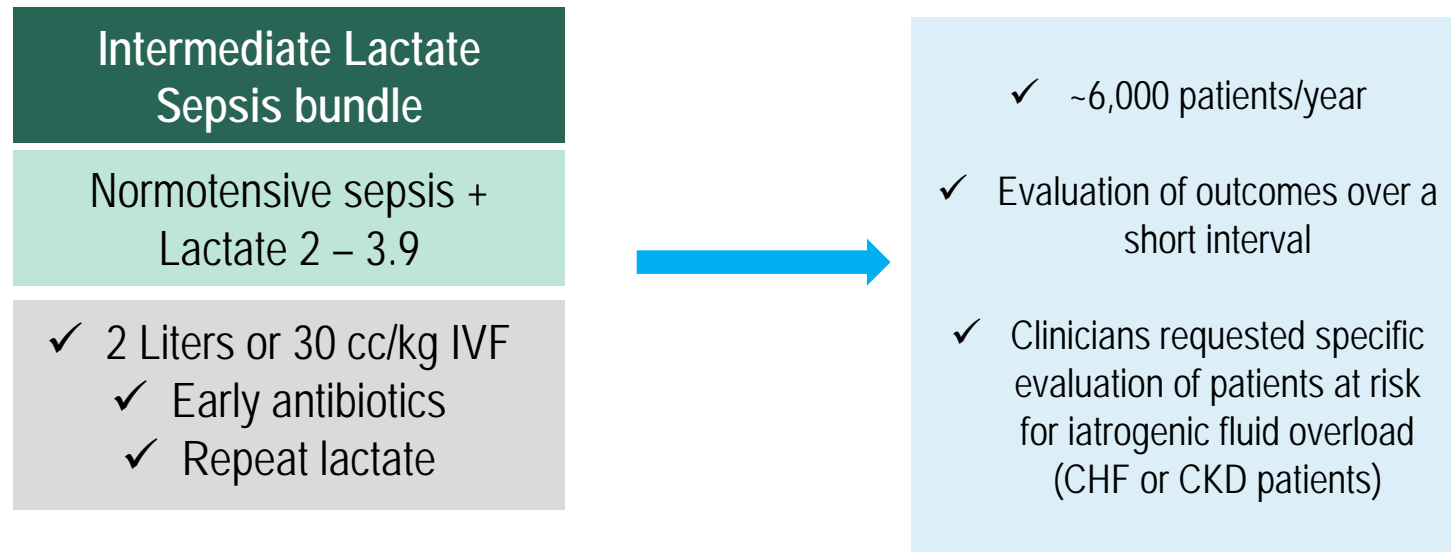
U-shaped association between fluid volume received and hospital mortality, with a plateau between 15-45 mL/kg

Figure 3. Mean hospital mortality among patients with decreased lactate within 8 hours of index test, stratified by total fluid received in increments of 7.5 ml/kg based on medication administration record.

Liu/Morehouse et al (Annals ATS 2013)

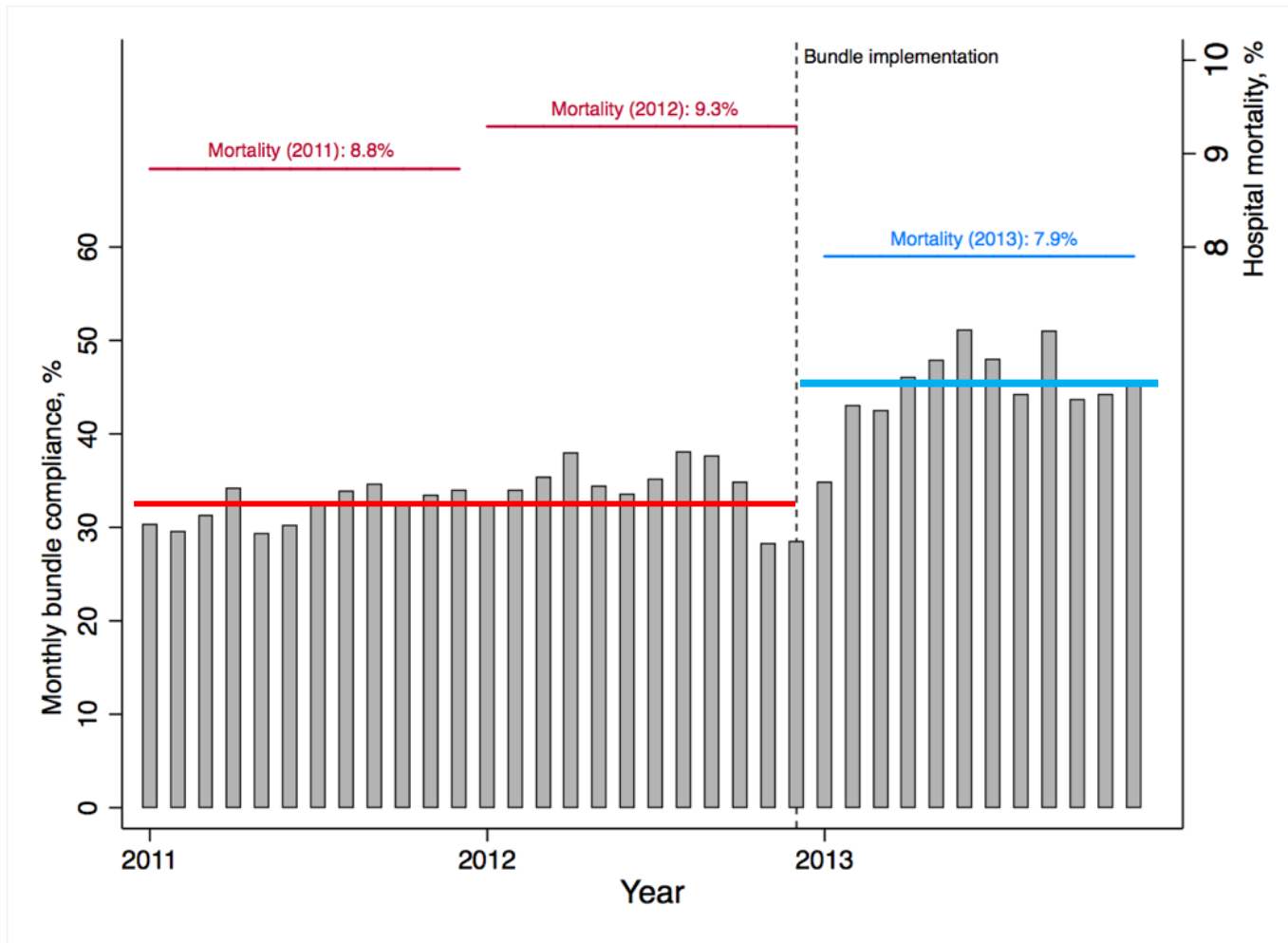
Sepsis: intermediate lactate patients

Instituting a bundle based on best evidence and sepsis principles



Sepsis: intermediate lactate patients

Bundle compliance before and after implementation



Sepsis: intermediate lactate patients

Outcomes stratified by history of CHF or CKD

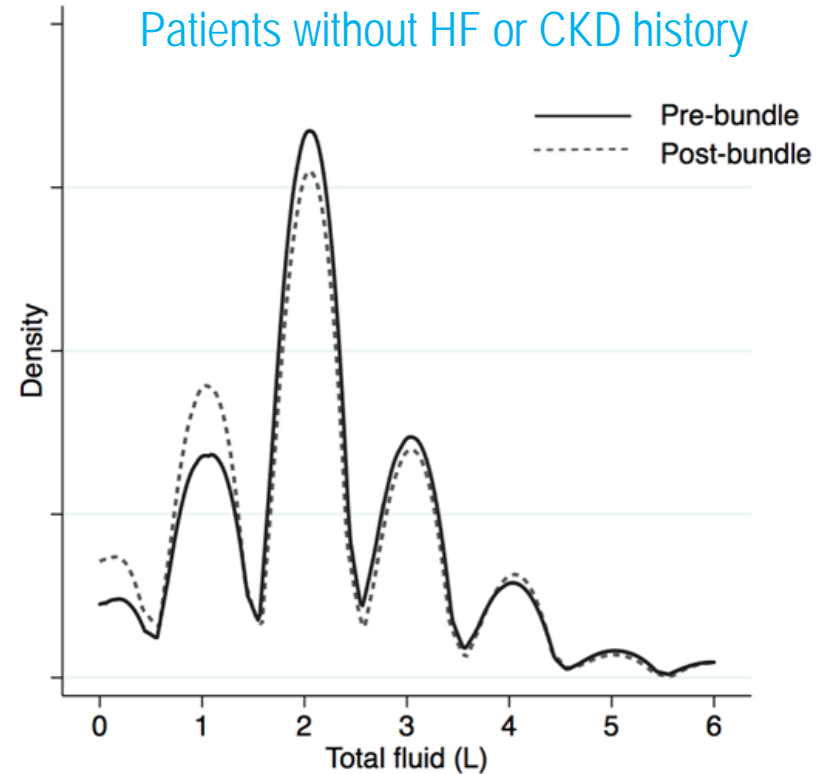
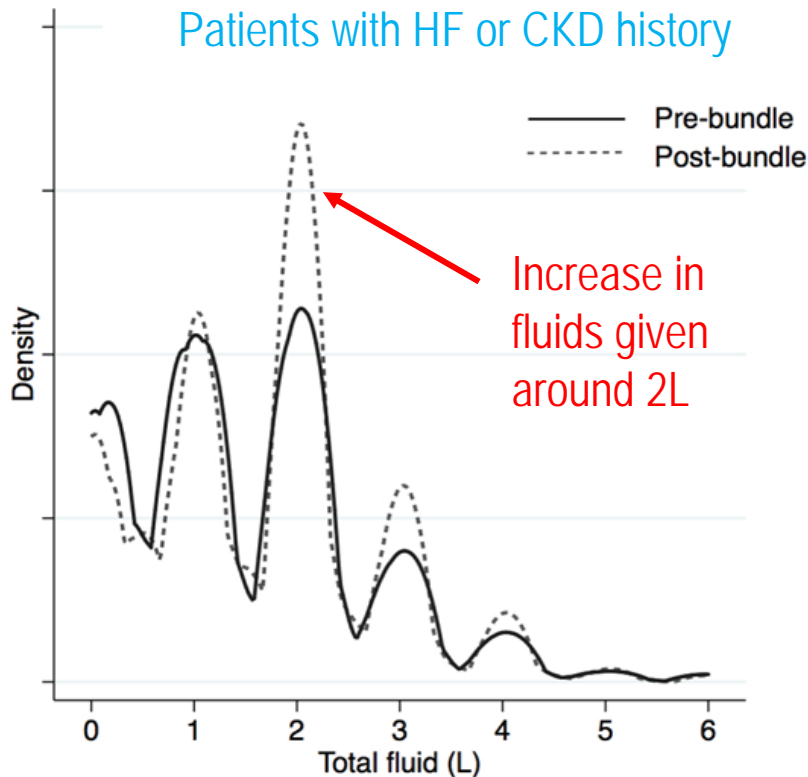
Mortality before and after IL Bundle Implementation

	<i>n</i>	2011	2012	2013	P-value
		Mortality (%)			
				IL Bundle Implementation	
All patients (hospital)	18,122	8.8	9.3	7.9	0.02
All patients (30-day)		13.7	14.1	12.6	0.03
CHF/CKD (hospital)	8,322	10.7	12.5	8.7	<0.01
CHF/CKD (30-day)		16.8	18.3	14.5	<0.01
No CHF/CKD (hospital)	9,800	7.4	6.5	7.2	0.40
No CHF/CKD (30-day)		11.3	10.5	10.8	0.60

Liu et al (AJRCCM 2015)

Sepsis: intermediate lactate patients

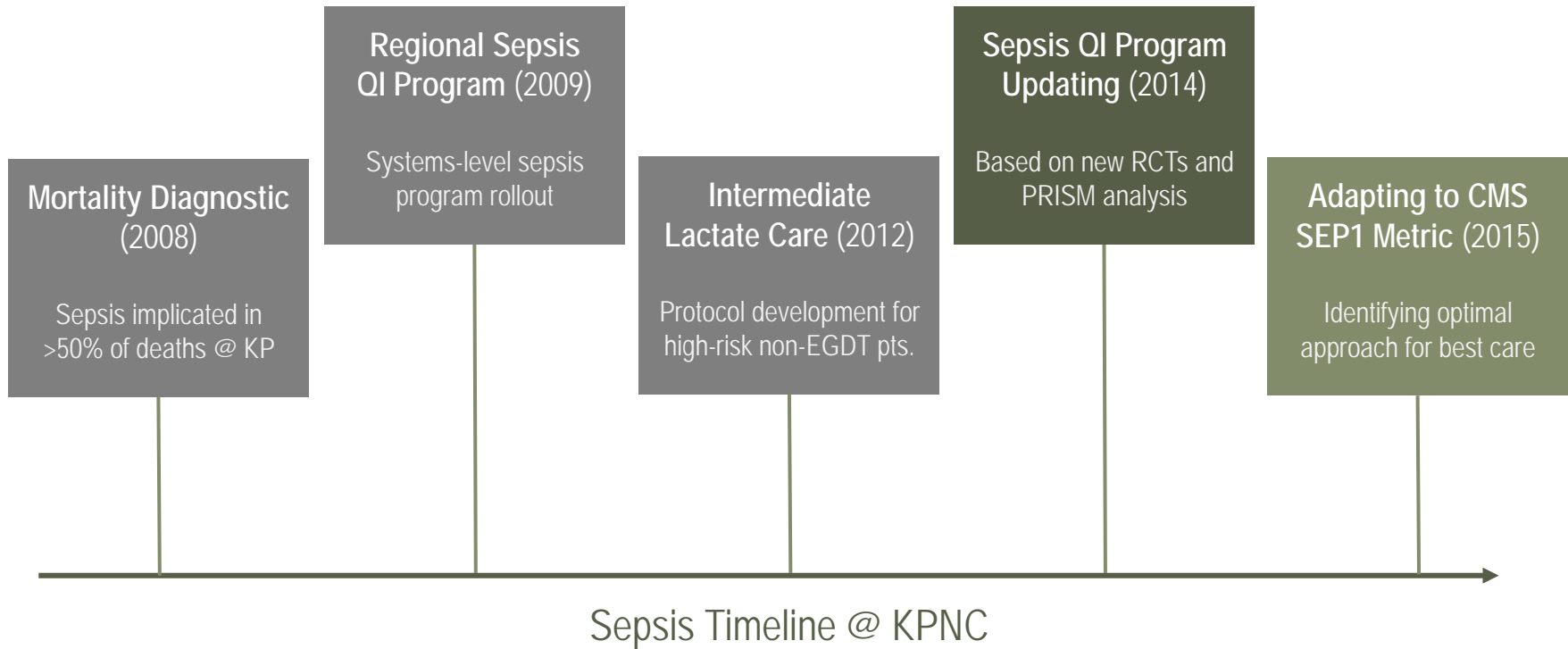
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Liu et al (AJRCCM 2015)

Sepsis: driving new discovery

Moving beyond EGDT



Liu/Morehouse et al (JHM 2016)

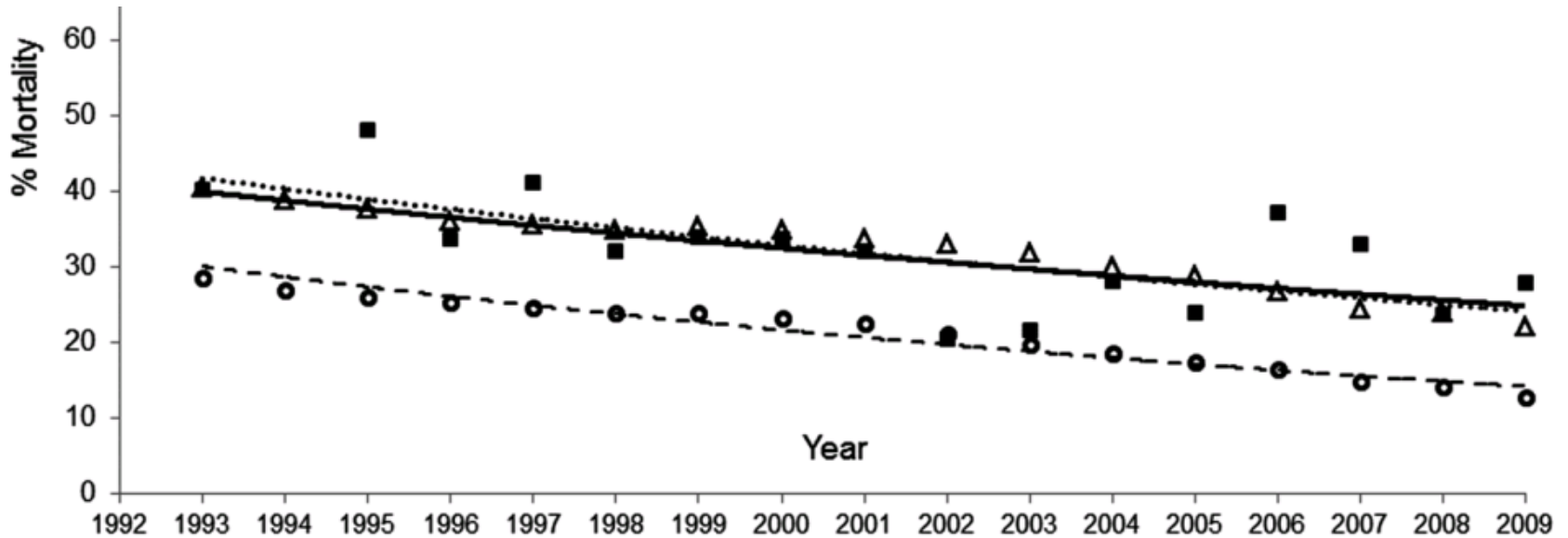
Sepsis: where are we today?

How do we best treat sepsis patients....



Sepsis: where are we today?

Trends in sepsis mortality over 2 decades



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of Trial subjects	544	No trials	863	1682	1554	1148	97	882	1799	1670	537	648	91	509	545	834	400
Number of 'Angus' definition ^a	5.83	6.59	7.27	7.79	8.22	9.02	9.29	9.51	10.3	11.8	13.4	15.1	17.0	18.8	21.1	25.0	27.2
Number of 'Martin' definition ^a	2.07	2.33	2.59	2.90	3.12	3.36	3.48	3.55	3.94	4.49	5.13	6.09	6.90	7.91	8.89	10.2	10.8

Stevenson et al (CCM 2014)

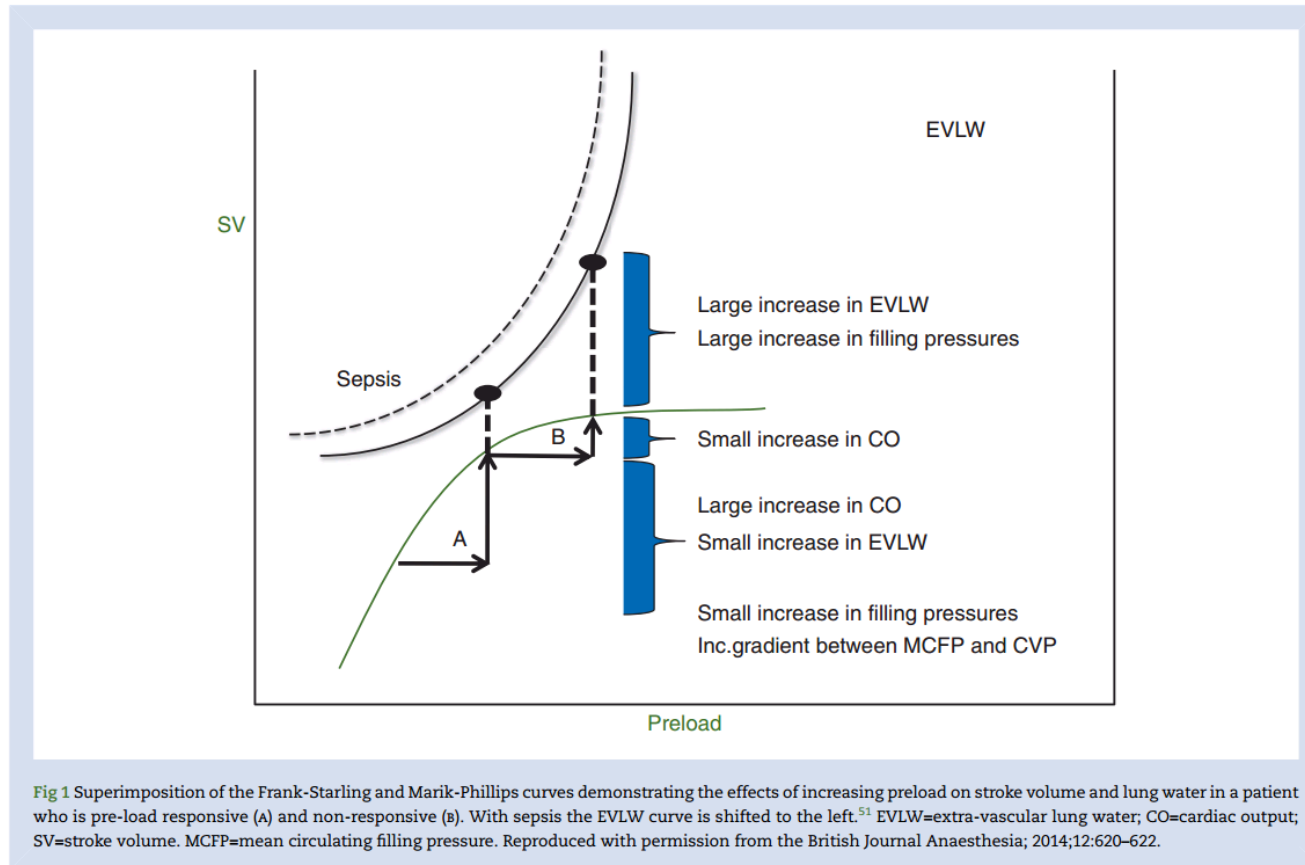
Sepsis: where are we today?

Principles for best sepsis care

- ✓ Educate your hospital staff about the massive impact that sepsis has on morbidity, mortality, cost, and utilization
- ✓ Develop a multidisciplinary team to deliver standardized, coordinated, and rapid sepsis care
- ✓ Aim to accelerate the identification of sepsis patients, particularly those at high risk for adverse outcomes
- ✓ Focus on source control through early antibiotics
- ✓ Build a data infrastructure that allows you to assess how sepsis program investments impact outcomes
- ✓ Fluids are frequently needed for sepsis patients, but recognize that they can have side effects
- ✓ Use dynamic clinical judgment, with ongoing patient reassessment

Sepsis: fluid management

Schematic of physiologic changes after fluid resuscitation



Marik and Bellomo (BJA 2015)

Sepsis: fluid management

Changes in 72h fluid totals over time

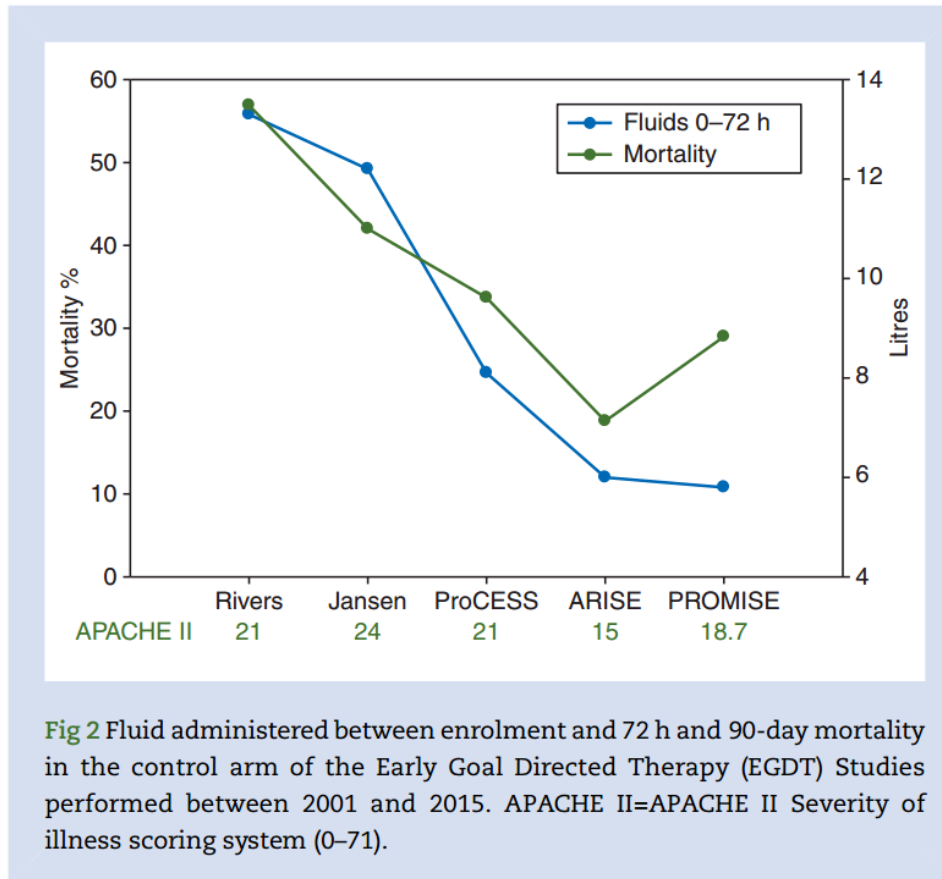
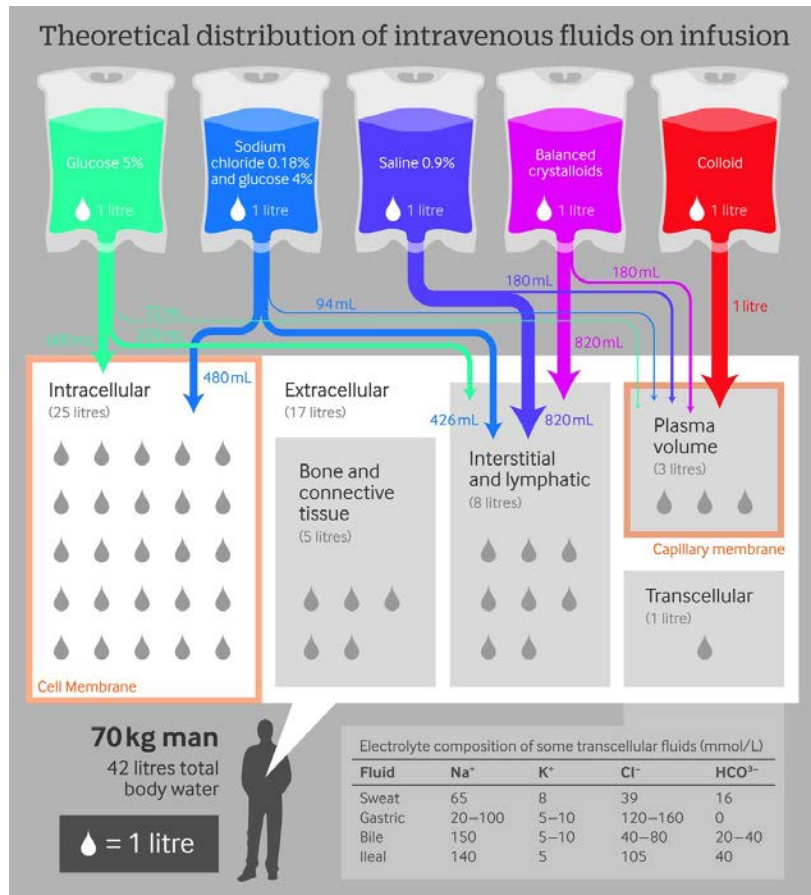


Fig 2 Fluid administered between enrolment and 72 h and 90-day mortality in the control arm of the Early Goal Directed Therapy (EGDT) Studies performed between 2001 and 2015. APACHE II=APACHE II Severity of illness scoring system (0-71).

Marik and Bellomo (BJA 2015)

Sepsis: fluid management

IV fluid type



IV Fluid Type

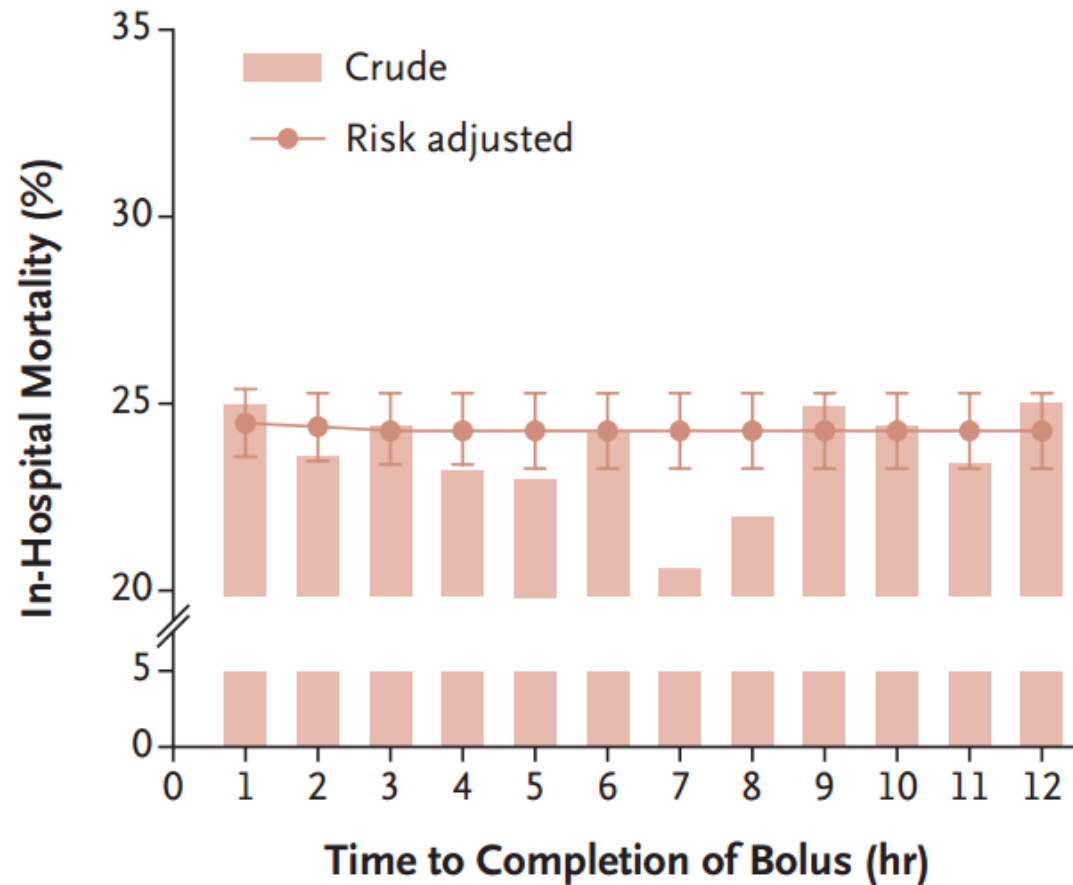
- ✓ No role for hydroethyl starch which was associated with increased mortality
- ✓ RCT data finds no definite benefit from albumin versus crystalloid
- ✓ However, there is evidence favoring improved mortality with albumin in certain subgroups – so, additional study needed
- ✓ There is evidence suggesting mortality benefit from balanced crystalloids; additional study is needed
- ✓ No clear reduction in renal replacement therapy

Frost (BMJ 2015)

Sepsis: fluid management

IV fluid timing

C Initial Bolus of Intravenous Fluids



Seymour et al (NEJM 2017)

Sepsis: fluid management

Frequent reassessment after IV fluids

Macrocirculatory *versus* Tissue Perfusion-Based Resuscitation Endpoints



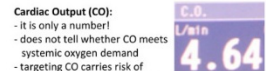
Central Venous Pressure:

- useless to assess volemia
- useful to monitor the cardiac response to fluid loading



Arterial Blood Pressure (ABP):

- low sensitivity/specificity to detect tissue hypoperfusion
- targeting ABP carries high risk of vasopressor overuse and monitor cosmetics
- useful to avoid ABP drops below lower limits of coronary/cerebral autoregulation
- good to predict mortality



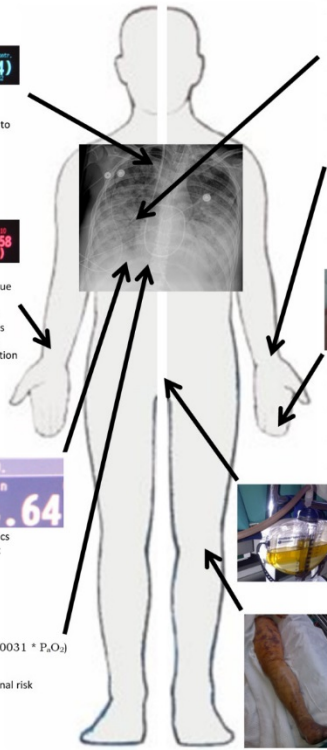
Cardiac Output (CO):

- it is only a number!
- does not tell whether CO meets systemic oxygen demand
- targeting CO carries risk of inotrope overuse and monitor cosmetics
- correlates with tissue perfusion only at extreme values

$$DO_2 = CO * (Hb * 1.36 * S_{O_2} + 0.0031 * P_{O_2})$$

Oxygen Transport Capacity (DO₂):

same as for cardiac output with additional risk of calculation errors.



Central/Mixed Venous Oxygen Saturation:

- indicates whether O₂ delivery meets demands
- high values indicate shunting or luxurious blood flow (rarely reduced O₂ consumption)
- measure continuously!
- prefer mixed venous measurements!
- false high measurements in case of severe peripheral vasoconstriction and/or sepsis
- good to predict mortality at low and high values

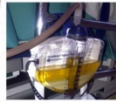
Arterial Lactate:

- marker of tissue hypoperfusion (with limitations) and disease severity
- good to predict mortality even at moderately elevated levels
- lactate clearance valuable to guide resuscitation
- other causes than tissue hypoperfusion can increase lactate levels (e.g. β₂-stimulation)
- currently only intermittent lactate measurements available



Capillary Refill Time/Peripheral Perfusion:

- indicator of adequacy of systemic blood flow
- continuous and quantitative measurement using S_{O₂} or the peripheral perfusion index
- does not exclude visceral organ hypoperfusion due to excessive vasodilation (rare)
- unreliable in severe peripheral artery disease and hypo/hyperthermia
- delayed response to treatment (15-60')



Urine Output:

- good marker of renal/visceral organ perfusion
- delayed response to treatment (15-60')
- unreliable in established kidney injury
- titration of fluids to urine output alone may result in fluid overload
- never treat shock-related oliguria with diuretics!
- minute-by-minute measurement of urine flow technically possible



Skin Mottling:

- skin over the knee caps mottles first!
- indicator of inadequate systemic blood flow
- never increase vasopressors in case of skin mottling! Mortality will be nearly 100%!



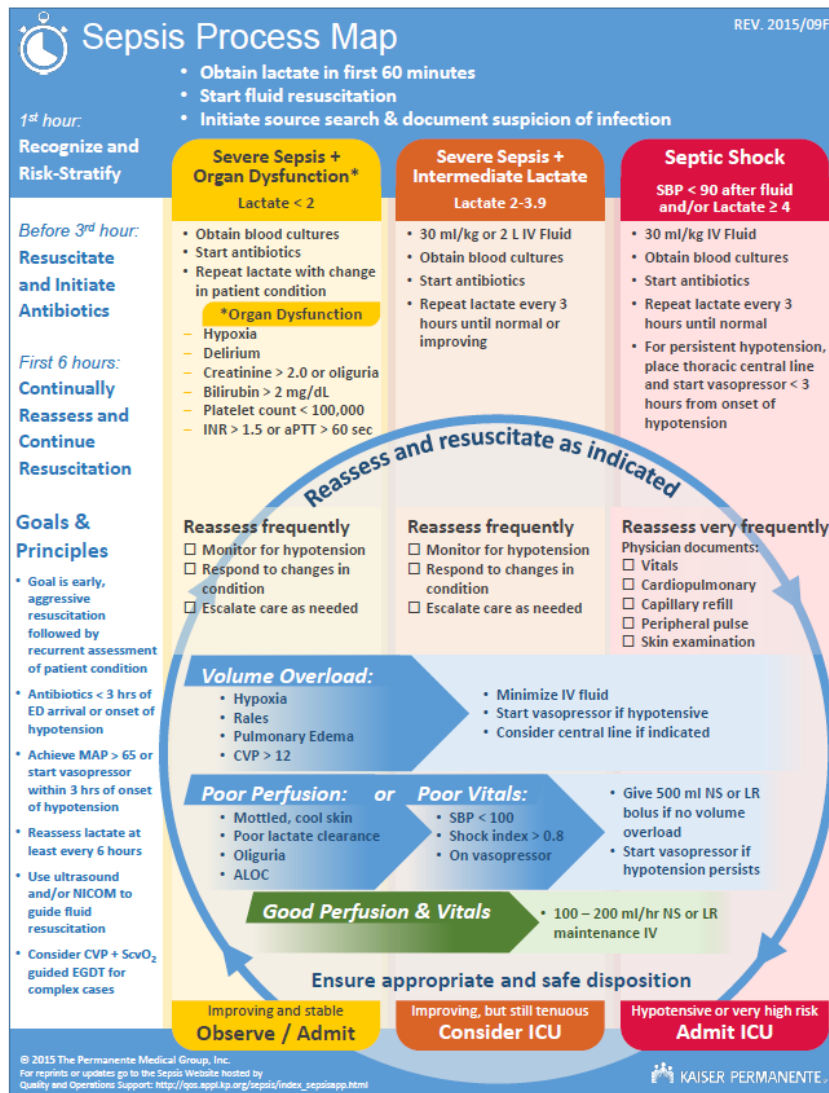
Dunser et al (Crit Care 2013)

Sepsis: where are we today?

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Sepsis: where are we today?



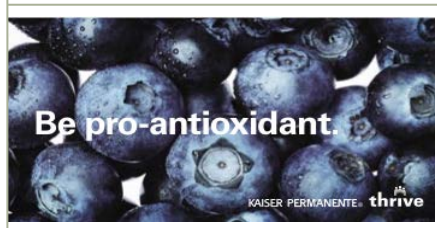
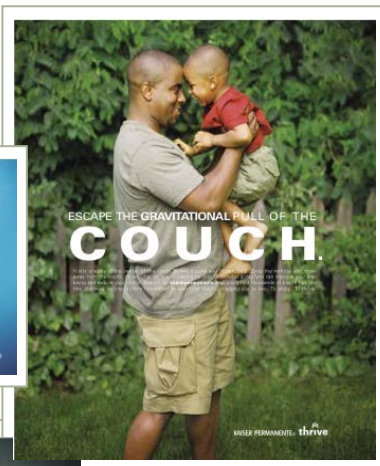
Sepsis: where are we going tomorrow?

Frontiers of sepsis care



Evolving Issues in Critical Care and Sepsis

Thank you



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